The Production of Trace Level Explosive Standards Using Drop-on-Demand Ink-Jet Printing Technology

With the constant threat of worldwide terrorism and the recent increase in the deployment of explosive detection devices, the detection of trace quantities of explosives at security checkpoints has become a national priority. Ion Mobility Spectrometry (IMS) is a commonly used explosive screening tool because IMS instruments are portable, durable, and capable of rapid detection of trace quantities of explosive materials. Tens of thousands of IMS instruments are currently deployed at airports, seaports, embassies, and also at government and military installations around the world. Standards are needed to optimize and calibrate these instruments. To meet this extensive need, we are developing procedures to use piezoelectric drop-on-demand ink-jet printing technology to produce standards that contain trace quantities of explosive materials. Ink-jet technology will allow standards to be rapidly produced. Also, large concentration ranges are possible simply by varying the number of drops printed.

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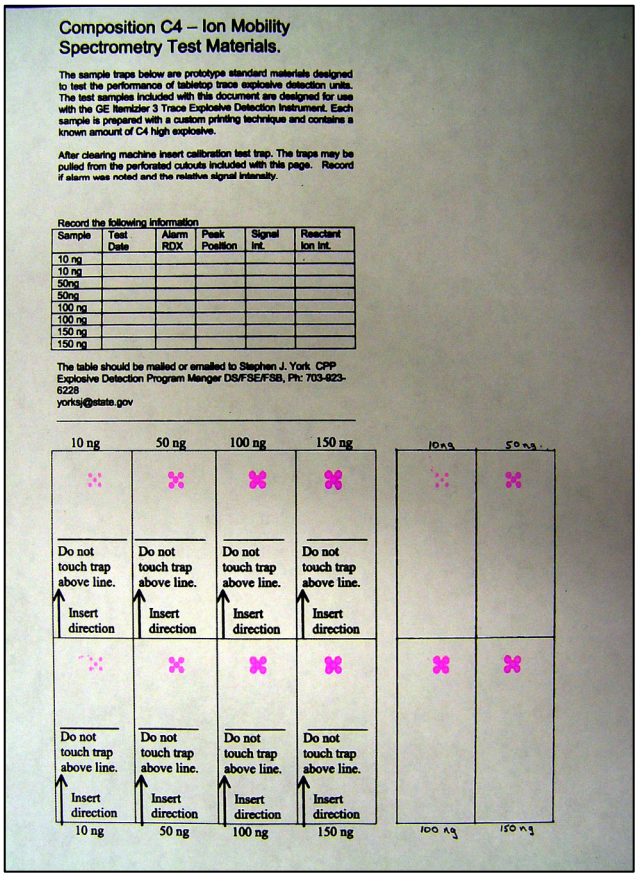
Piezoelectric drop-on-demand ink-jet printing is a rapidly expanding technology with highly varied applications ranging from microelectronics to tissue engineering. Printing of standards is a new application of the technology and one that requires a level of process control and characterization that has not previously been demonstrated. For standards production, the reproducibility of the ink-jet printer is critical. Reproducibility however is not trivial and many factors will affect the quality of the printed standard. For example, physical properties such as viscosity and surface tension of the solution being printed must fall within a relatively narrow range to allow reliable printing. Also, small changes in the print-head reservoir pressure, the drop generation frequency, and the electrical signal driving the piezoelectric crystal will change the drop volume and therefore alter the quantity of standard that is printed. Ink-jet tips are also prone to clogging and misfiring and this will adversely affect standards production.

We are currently investigating techniques to determine the reproducibility of the printer and measure the quantity of explosive printed. Techniques such as GC-MS, gravimetry, and the quartz crystal microbalance are being used to determine both the reproducibility of printing and the quantity of the printed material. Drop counters have been constructed to record the actual number of drops generated, and various optical imaging procedures are being used to monitor droplet formation and measure the uniformity of droplet deposits on substrates. Feasibility has been demonstrated for the printing of numerous explosives including TNT, PETN, and plastic based explosives such as C-4.

The figure is a prototype sheet of printed explosive standards. The explosive is C-4 that has been combined with rhodamine dye to allow visibility of the printed explosive. Standard concentrations of (10, 50, 100 and 150) ng of C-4 are printed.



It is anticipated that current work on the characterization and metrology of ink-jet printing will be applicable to the future production of a diverse range of standard materials.

Impact: Development of standard materials for testing trace explosives detection equipment is a major national priority and will help to ensure public safety.